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THE SO-CALLED ALKALI SPOTS OF THE YOUNGER DRIFT-SHEETS

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The surface of cultivated fields on the younger sheets of glacial drift in Iowa, Wisconsin, Illinois, and Indiana is frequently marked by patches of a white efflorescence which is distinctly hostile to many cultivated plants, particularly corn. These patches have received the name of "alkali spots" from the farmers of the region, to whom they are a source of perplexity and loss.

Genetically, these "alkali spots" are invariably connected with the small sloughs or lakelets which characterize the extreme topographic youth of drift-sheets. As is well known, the surface of the Wisconsin drift is pitted with countless thousands of these small bodies of water; the Iowan drift bears them in notably smaller proportion, a circumstance in harmony with the more advanced development of the natural drainage of this drift-sheet. In their undrained condition these basins are a hindrance to agricultural operations, although in general the water may readily be removed by drainage; this is being done on an enormous scale in the states mentioned. In a very large number of cases, however, the farmer, after doing away with the standing water, finds the reclaimed land affected by the harmful efflorescence mentioned above.

Analysis shows the efflorescence to consist of small amounts of sodium chloride and much larger amounts of the carbonates and sulphates of magnesium and calcium; magnesium sulphate is a leading constituent. Sodium carbonate is absent; the efflorescence lacks therefore the character of a true alkali, and the soil infested with it is not an alkali soil, as this term is understood in the semi-arid West. The hostility of the soil of the "alkali spots" to corn is due to the presence of excessive amounts of magnesium salts in the soil moisture.

The *raison d'être* of the efflorescence is not far to seek. It will be

borne in mind that many of the innumerable sloughs of the younger drift-sheets occupy the lowest points of depressions without outlet. These depressions constitute isolated basins having an area varying from two or three up to as many hundreds of acres in extent. The floor of these basins consists of the finely pulverized rock-flour characteristic of the ground moraine. Owing to its fineness, the material of the till is in the most favorable condition to be attacked by the agencies of weathering. The alkaline-earth carbonates are attacked and rendered soluble by the carbon dioxide of the air; the sulphur in the pyritiferous minerals of the till is oxidized and converted into sulphuric acid, which ultimately appears in the form of its calcium and magnesium salts. Doubtless a certain proportion of the material dissolved out of the till enters the general underground circulation, but a large part simply collects in the water which has found its way to the lowest part of the basin and has there been concentrated by evaporation. Since the final retreat of the ice, this process of concentration has in many cases brought the percentage of dissolved matter up to a figure quite beyond that which is usual for surface water. This is especially true of small ponds which receive the drainage of large areas; but even those located in small basins frequently contain appreciable amounts of salts, as is apparent from the white residue left on their floors when they dry up in summer. Many of the lakelets of the drift are, on a small scale, embryo salt lakes, in which magnesium sulphate instead of sodium chloride is the principal dissolved substance.

The earth in their vicinity is consequently saturated with water carrying a notable amount of saline matter, chiefly soluble salts of magnesium. When the farmer tiles out the basin, the excess of water is drawn off through the drains. Much of the dissolved magnesium is thus removed, but not all, for no drain will at once remove all of the water; even the percolation of the rain water of several successive seasons is frequently insufficient to wash out all of the deleterious salts.¹ Although these

¹ This will be understood by every student of chemistry who has had occasion to wash a dense precipitate to free it from a soluble salt. The obstinate retention of certain salts freely soluble in water by a finely divided solid is not always purely mechanical. The phenomena of adsorption (*adsorption* is different from *absorption*), of which chemists have only recently begun to take account, come largely into play.

salts are slow to find their way out of the soil through the drains, capillary flow during dry weather readily brings them to the surface, where evaporation raises the percentage of magnesium in the soil moisture in the zone of root-growth beyond the point of toleration by the plants; continued evaporation of the surface moisture produces the efflorescence.

If the floor of the slough was originally somewhat peaty, and therefore porous, the efflorescence is fairly evenly distributed over the area formerly occupied by the water; but if, as is more usually the case, the slough has been silted up with fine material, the efflorescence appears in a zone corresponding to its former margin. It is the occurrence of this annular area of barren ground in an otherwise productive field which mystifies the farmer and the agricultural writers.

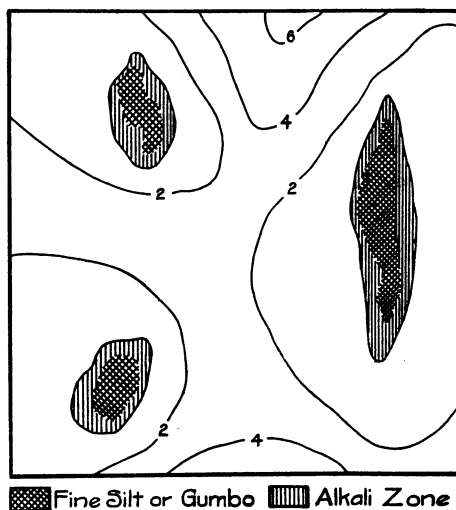


FIG. 1.—Group of small annular “alkali spots” on the Story County Poor Farm, Iowa.
(Horizontal scale: 1 inch = 200 feet.)

The occurrence of this annular zone of poisonous soil is accounted for on the following considerations: The surface water which finds its way into the slough carries with it both fine and coarse material; the particles of the grade of sand are deposited first, while the silt is distributed farther from the border. The soil and subsoil of the margin are consequently more open-textured than the soil of the interior; hence there is a predominant flow of capillary moisture toward the porous margin, where evaporation renders conspicuous both the efflorescence, and the poisonous condition of which it is the sign.

The essential features of typical “alkali spots” are shown in the accompanying figures.

Adsorption is undoubtedly a considerable factor in geological chemistry, and should receive greater attention from soil investigators.

It is a matter worthy of remark that the immediate surface of the Iowan drift-sheet seems to be much poorer in soluble sulphates than is the case with the Wisconsin. The Iowan has its "alkali spots," to be sure, but their occurrence is due to the preservation of favoring topographic conditions. Where natural drainage has

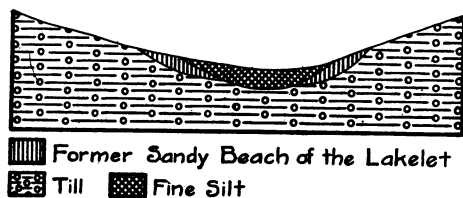


FIG. 2.—Section through an "alkali spot."

long been established, as in the vicinity of the master-streams, the proportion of soluble sulphates in soils of the Iowan drift is quite normal. It appears to be otherwise with the Wisconsin drift, even in the broken

area adjacent to the streams which flow across the tip of the Des Moines lobe south of the Gary moraine; in this region is to be found that part of the Wisconsin drift which, in Iowa at least, has been longest exposed to weathering, since it was the first to be left bare by the retreating ice. Close examination of hillside surfaces in this area after several days of fine weather often reveals the presence of an efflorescence similar in appearance to that found in the "alkali spots;" the presence of soluble sulphates is easily shown by scraping about twenty grams of earth from the surface, extracting with pure water and adding a solution of barium chloride, whereupon a copious precipitate of barium sulphate will be obtained. This appears to be a point of difference between the surfaces of the two drift-sheets.

It will be recalled that in estimating time ratios within the glacial epoch much weight has been laid upon the obvious differences in the present condition of the upper zones of the various drift-sheets. The absence of lime, the decay of the feldspars, the complete oxidation of the iron content so unmistakably patent in the ferretto of the Kansan clearly stamp this till as of greater age than that made by later ice-sheets. No such obvious differences set off the later tills one from the other. The difference between the surface zones of the Iowan and Wisconsin tills in regard to lime content is not particularly noticeable, and the same may be said of the degree of oxidation of the iron in these tills; the granite boulders of the Wisconsin are not noticeably fresher in appearance than those of the Iowan. The chemical criteria

heretofore in use are apparently not sufficiently delicate to differentiate such recent glacial deposits.

The writer's personal observations are perhaps much too limited to warrant the assertion that a criterion of the required delicacy has been obtained, but there will be no harm in expressing the opinion that more extended observations will probably confirm the preliminary indications. There are abundant reasons for assuming *a priori* that in the earliest stage of the after history of a drift-sheet it will be characterized by a noticeable amount of sulphates and that these will begin to disappear long before any appreciable diminution of calcium carbonate or decomposition of ferro-magnesium minerals have occurred—granted, of course, that the drift contains pyritiferous minerals, which in fact is always the case. Pyrite is peculiarly susceptible to the action of moist oxygen and its conversion into ferrous sulphate and free sulphuric acid follows its exposure to the dissolved oxygen of the ground water. Considering the relatively small amounts of pyrite and sulphates in the drift as compared with calcium carbonate, the great excess of atmospheric oxygen over atmospheric carbon dioxide, and the great solubility of the sulphates as compared with the solubility of calcium bicarbonate, it is quite natural to expect that the surface of the till will be desulphurized much sooner than it will be decarbonated.